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I

Vertebrae Counts and Brood Strength Variations of young fish

By

GUNNAR SELMER SÆTERSDAL
Directorate of Fisheries, Institute of Marine Research

1952

A.s John Griegs Boktrykkeri, Bergen

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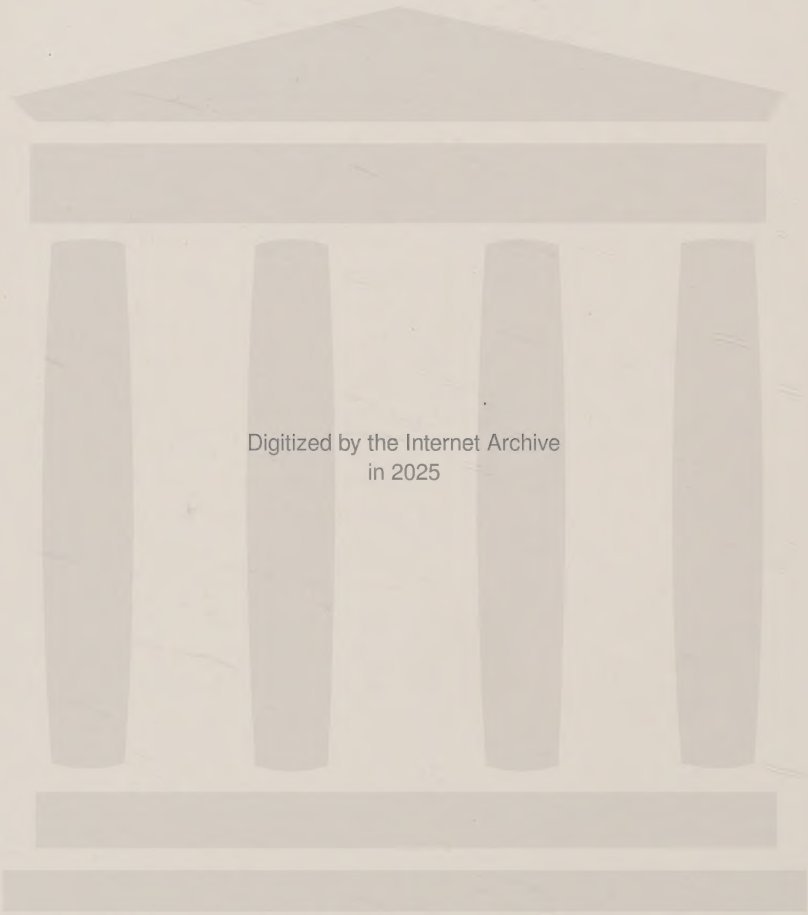

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Introduction.

The following paper deals with the results of some research carried out on young haddock from northern Norway and the Barents Sea.

I am greatly indebted to Director Gunnar Rollefsen and Fishery Consulent Gunnar Dannevig for their kind advice and help.

In the north the haddock is distributed from Spitsbergen and the Barents Sea, along the Norwegian coast to the North Sea, the Faroes and Iceland. The populations and spawning areas of the haddock in the North Sea, the Faroes and Iceland have been thoroughly investigated by Scottish and Icelandic biologists, whereas little is known of the life history of the Norwegian and Barents Sea haddock. That these areas are populated by perhaps the largest haddock stocks in European waters, is revealed by the fact that the total yearly catch of haddock from the Bear Island, the Barents Sea and the Norwegian Sea during the years before the last war, exceeded that of the North Sea, and amounted to about 40 % of the total European catch of haddock.

Of primary importance is the question whether the haddock in these northern areas constitute one or several main populations. It is felt that some of the results arrived at in the investigations of young haddock mentioned below may throw some light on this question.

Material.

The Investigation of haddock in Norwegian waters was begun in 1948 at The Institute of Marine Research, Bergen by the author. Starting with an investigation of the methods of age and growth determination of haddock, (the results of which will be published later), it was natural at first to concentrate on young haddock of the 0-, I-, and II-groups. Samples of these age-groups could easily be obtained from prawntrawl-catches all along the coast of northern Norway.

The localities from which the samples referred to in this paper have been taken are plotted in fig. 1. The material from the Brandsfjord at 64° N consists of 29 samples taken at almost regular intervals by Mr. Erling Søreng from his prawntrawl-catches during the period September 1948 to August 1951 for the purpose of the above mentioned investigation. The samples from the other localities, have been collected during cruises with the research vessels "Johan Hjort" and "G. O. Sars".

Vertebrae Counts.

In some of the samples the number of vertebrae were counted. In the cases where the original samples were too numerous, subsamples of about 120 were selected for counting, care being taken that the subsamples had about the same pattern of length frequency distribution as the original samples. Where possible, the yearclasses have been kept separate, the otoliths having been used to determine the age.

In analysing the results the analysis of variance has been used (Bonnier & Tedin 1940). In the tables, the following abbreviations have been applied.

N: number of fish,
$\bar{V}$: average number of vertebrae,
D.f.: degrees of freedom,
S.S.: sum of squares,
M.S.: mean square,
v^2: quotient between the greater and smaller mean squares.

Table 1 shows the frequency distribution and the average number of vertebrae in 16 samples of the 1948 yearclass. The mean square between the samples is less than the mean square within. The value of P is greater than 0,2, i.e. the differences between the samples are not significant.

In table 2 the vertebrae numbers in 4 samples of the 1950-yearclass are listed. The value of P shows that the differences between these samples are significant. If, however, the sample from Ona (the southernmost locality at abt. 62° N) is kept out of the calculations, the v^2 for the remaining 3 samples gives a P value which strongly approaches 0,05, the figure which is usually considered the limit between significant and non-significant values.

Some observations on the vertebrae count of young haddock taken at the Institute of Marine Research, Bergen, previous to this investigation, were also available. This material cannot be separated in year-

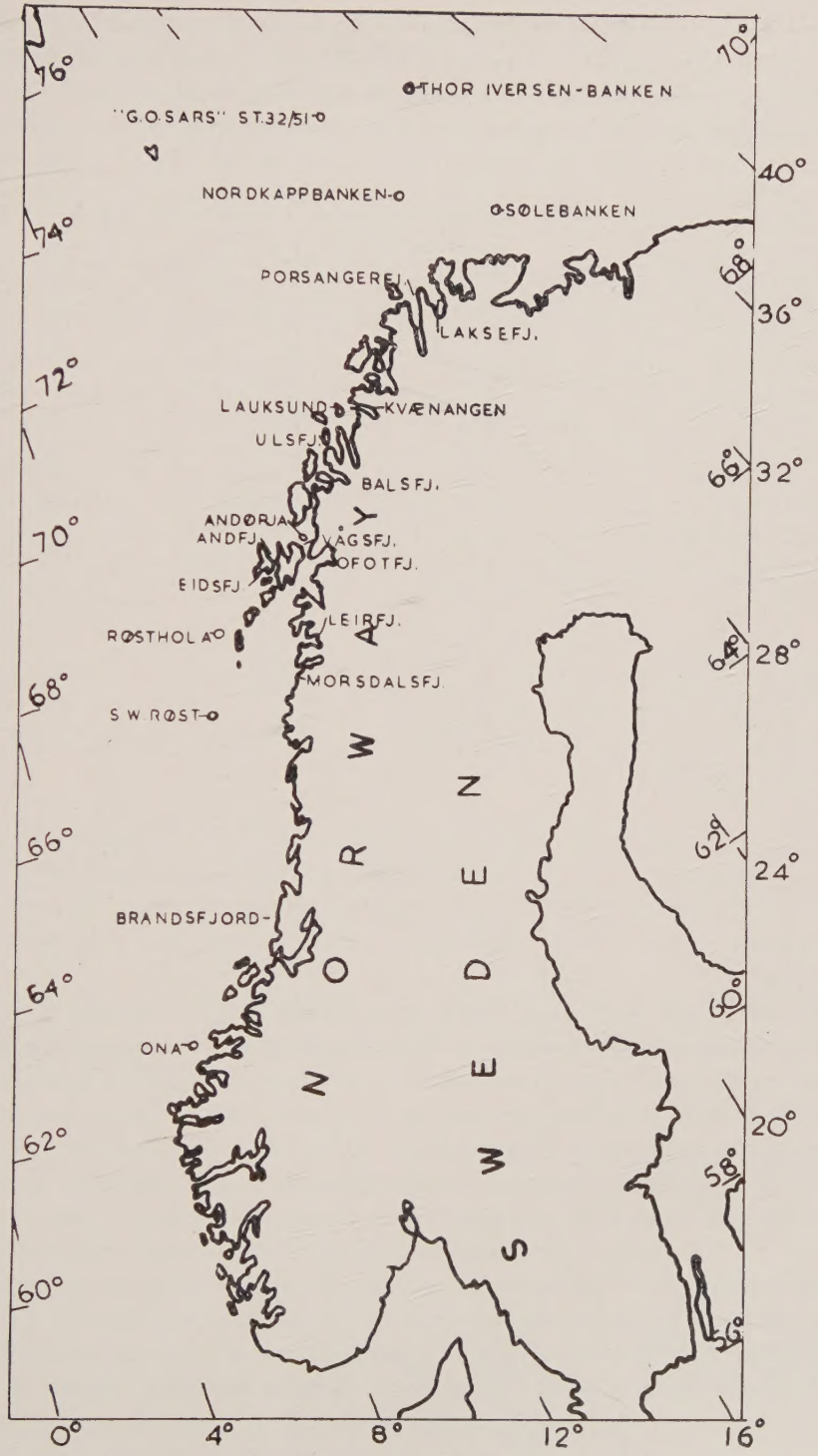

Fig. 1. Map showing the localities from which the samples have been taken.

Table 1. *Number of vertebrae of 1948-yeargroup.*

Locality. Date	51	52	53	54	55	56	57	N	$\bar{V}$
Brandsfjord ..... 2/9+9/10—48		2	22	78	22	2		126	54,00
Morsdalsfjord ..... 25/9 —48	1	4	30	56	31	2		124	53,95
Ofotfjord ..... 10/11 »			28	72	23	2		125	53,99
Ulsfjord ..... 16/10 »			34	68	20	1		123	53,91
Kvænangen ..... 19/10 »		1	30	72	16	2	1	122	53,93
Porsangerfjord ..... 23/10 »		2	27	69	23	1		122	53,95
Andfjord ..... 3/11 »		2	35	78	12			127	53,79
Brandsfjord ..... 24/10—49		3	19	65	22	1		110	53,99
Ulsfjord ..... 10/10 »		1	20	86	22	1		130	54,02
Kvænangen ..... 13/10 »		4	27	60	26	2		119	53,96
Eidsfjord ..... 28/9 »			24	65	23	1		113	54,01
Andfjord ..... 27/10 »		3	27	64	17	2		113	53,89
Porsangerfjord ..... 18/10 »		1	19	26	21			67	54,00
Brandsfjord ..... 27/2 —50		2	23	62	27			114	54,00
Tor Iversen bank ..... 27/4 »			27	61	24	3		115	54,03
Porsangerfjord ..... 3/5 »		4	31	85	25	4		149	53,96
							Total:	1899	53,96

	S.S.	D.f.	M.S.
Between samples	6,72	15	0,4450
Within samples	996,99	1883	0,5294

$$v^2 = \frac{0{,}5294}{0{,}4450} = 1{,}19 \;) \; : \; P > 0{,}2$$

Table 2. *Number of vertebrae of 1950-yeargroup.*

Locality	Date	52	53	54	55	56	57	N	$\bar{V}$
Vågsfjord	6/10—50	1	14	42	19	5		81	54,16
Ulsfjord	22/9 »		19	64	30	6		119	54,19
Brandsfjord	27/9+10/11		24	49	20			93	53,96
Ona	24/10—50	2	14	37	5			58	53,78
							Total:	351	54,05

All 4 samples:

	S.S.	D.f.	M.S.
Between samples	8,62	3	2,87
Within samples	172,35	347	0,49

$$v^2 = \frac{2{,}87}{0{,}49} = 5{,}86 \;) \; : \; P < 0{,}001$$

Ona omitted:

	S.S.	D.f.	M.s.
Between samples	3,49	2	1,75
Within samples	148,27	290	0,51

$$v^2 = \frac{1{,}75}{0{,}51} = 3{,}49 \;) \; : \; 0{,}05 > P > 0{,}01$$

classes, but judging by the length-frequencies of the samples, they consist of the 0-group, or the I-group, or a mixture of these. Table 3 shows the vertebrae-counts in these 14 samples, and the result of the analysis of variance. The differences between the samples are not significant.

Table 3. *Number of vertebrae of young haddock from Northern Norway. (Previous observations).*

Locality	Date	52	53	54	55	56	57	N	$\bar{V}$
Lauksundet	2/9—35	1	20	88	41	1		151	54,14
Andørja	21/9 »		23	75	40			138	54,12
Laksefjord	21/9—36	1	23	45	24	2		95	54,03
Kvænangen	29/9 »		17	50	28	2	1	98	54,18
Vågsfjord	3/10 »		32	52	13	3		100	53,87
Kvænangen	27/8—37	6	34	104	42	3		189	54,01
Kvænangen	27/8 »	3	24	72	30	1		130	54,02
Morsdalsfjord	4/9—46		12	54	26	5		97	54,25
Andørja	16/9 »	1	27	88	56	3		175	54,19
Balsfjord	17/9 »	1	15	94	45	5		160	54,24
Ulsfjord	21/9 »		24	89	44	4		161	54,17
Lauksundet	23/9 »		29	59	21			109	53,93
Kvænangen	24/9 »	1	10	64	25			100	54,13
Andfjord	14/10 »	3	34	119	52	2		210	54,08
							Total:	1913	54,10

	S.S.	D.f.	M.S.
Between samples	11,33	13	0,8738
Within samples	965,37	1899	0,5072

$$v^2 = \frac{0{,}8732}{0{,}5072} = 1{,}723 \;) \; : \; 0{,}05 < P < 0{,}2$$

The samples in table 3 have as a whole somewhat higher average numbers of vertebrae than the samples in table 1. This suggests that the number of vertebrae may vary from one yearclass to another. But as the working up of the whole material has been somewhat heterogenous, and as it is impossible to separate the material in table 3 in yearclasses, there is no basis for a further discussion on that question. The two tables 1 and 3 consist of samples from the same main area, and within each of them there are no significant differences.

Apparently there are no significant geographical variations in the number of vertebrae of haddock in the whole area from the Brandsfjord northwards. Further material is needed to ascertain whether the haddock farther south of the Norwegian coast really have a lower number of vertebrae as indicated by the single sample from Ona.

In a discussion of the significance of this uniformity of vertebrae numbers, it is of importance to know the variations found in the vertebrae-counts of haddock from other areas. TÅNING (1935) gives the following ranges of the average number of vertebrae of haddock:

Western Atlantic: 53, 88—54, 12
Eastern Atlantic:
Ireland: 53, 84
Faroes: 53, 88—53, 89
Iceland: 53, 86—54, 05
North Sea: 54, 01—54, 07
Norway (S .of Lof.) 54, 10—54, 15.

This data is unsuitable for a statistical comparison with my observations. But it is obvious that the differences in the average vertebrae number of haddock from these areas are small indeed. On the coast of North America, VLADYKOV (1935), on the other hand, was able to separate between three distinct haddock races with different ranges in the average number of vertebrae:

New Foundland race: 52,5—52,9
New England race: 53,1—53,2
Nova Scotian race: 53,5—54,3

This indicates that the vertebrae number may be a criterion of populations of haddock. But the small differences in the average vertebrae numbers of the various European populations suggest that too much weight should not be placed on the observed uniformity of vertebrae numbers in a discussion of the haddock population of Northern Norway and the Barents Sea.

Variations in brood strength.

It is generally known that in a fish population, the reproduction of the various years may result in very different numbers of fry. Uniformity in pronounced variations in brood strength within an area is usually considered as an indication that the species in question is recruited from one and the same spawning ground and spawning population.

In the samples of young haddock from the northern Norwegian areas there appeared to be very pronounced brood strength variations. In table 4 the age distributions of the samples are given. Most of the samples have been taken from prawn trawl catches, while in some instances a big commercial fish trawl has been used. For the purpose of further calculations, I have assumed that in the catches of the prawn trawl, only the two lowest age groups (the 0- and I-groups or the I- and II-

groups) are representatively present, older fish being in part able to escape this slow-moving gear. On the other hand in the samples from the fish trawl, only the II-group and older fish have been used for calculations, since large numbers of the 0- and I-groups probably escape through the meshes. In the last four samples listed in table 4, fish older than two years have been altogether excluded from the age distribution tables, due to a suspicion of selective sampling from the catches. The 0-group usually appears in the prawn trawl catches in September each year, but to be on the safe side, samples of 0-group caught earlier than November have not been used for calculations.

The best expression of brood-strength probably would be a measure of the density of the 0-group at the bottom in the first winter, such as mean catch per unit time and gear during a period of time. As it has been impossible to apply this method, I have instead made use of the quotients between the numbers of each two subsequent yeargroups which are considered adequately present in the samples, see table 4. These quotients do not show the true variation in brood strength since the older one of the two yeargroups compared has been exposed to reduction for an additional year. But if it is assumed that the death rate is approximately constant (and above all does not vary with the strength of the yeargroup), the quotients will always be the same fraction (less than 1) of the values which one would have obtained if the yeargroups were compared at the same age.

On account of the great differences in the brood strengths and the relatively small samples used, small chance variations in the weakest represented yeargroup will cause great variations in the quotients. Therefore no ordinary statistical treatment of the figures in table 4 has been attempted. But from the ranges and mean values of the quotients shown in table 5, it is evident, that in the investigated area, the yeargroups of 1947, 1948, 1949, and 1950 were represented by numbers of fry, the proportions of which were quite characteristic.

Growth.

Some valuable information concerning the subject of this discussion may also be obtained from observations on the growth history of young haddock in the area. Table 6 shows the mean lengths of some samples of the 1948 and 1950 yeargroups. The stagnation period in which no growth takes place, is from November—December until March—April. Samples taken near this time of the year are preferable when comparing growth-rates.

Table 4. *The age-distributions and brood-strength-quotients of the samples.*

Locality	Date	Gear	N	Yearclass						47/48	48/49	49/50
				—45 & older	—46	—47	—48	—49	—50			
Brandsfjord	6/11—48	Prawntrawl	221		1	10	210			0,048		
»	9/12 »	»	431	3	6	47	375			0.125		
»	29/1 —49	»	179		1	16	162			0,099		
»	19/2 »	»	205		2	14	189			0,074		
»	14/3 »	»	206		3	15	188			0,080		
»	27/4 »	»	189		2	18	169			0,107		
»	8/6 »	»	427	1	6	18	402			0,045		
»	1/7 »	»	178		3	6	169			0,035		
»	26/7 »	»	170		3	28	139			0,202		
»	12/9 »	»	148		1	12	134	1		0,090		
»	24/10 »	»	325			10	306	9		0,033		
»	24/11 »	»	276		4	11	246	15			16,4	
»	18/1 —50	»	241			14	215	12			17,9	
»	27/2 »	»	136				115	21			5,5	
»	20/3 »	»	106			6	86	14			6,2	
»	30/5 »	»	85			6	75	4			18,8	
»	24/6 »	»	57			5	44	8			5,5	
»	25/7 »	»	61			2	54	4	1		13,5	
»	30/8 »	»	73				27	11	35		2,5	
»	10/11 »	»	98			1	16	12	69			0,174

»	5/12 »	»	133				11	18	104			0,173
»	13/1 —51	»	114			2	10	15	87			0,172
»	22/2 »	»	125			1	12	13	99			0,131
»	28/3 »	»	166				3	14	149			0,094
»	7/7 »	»	108				2	4	102			0,039
»	27/8 »	»	95				3	3	89			0,034
Ofotfjord	10/11—48	»	221	5	8	24	175			0,137		
»	10/8 —49	»	175	1	4	23	137			0,168		
Eidsfjord	28/9 »	»	204		2	10	189			0,053		
Porsangerfjord	23/10—48	»	171	8	7	14	142			0,099		
»	18/10—49	»	108		1	2	70	25		0,029		
»	3/5 —50	»	208	3	18	21	159	6		0,132	26,5	
»	29/9 »	»	122			2	110	6	3	0,018	18,3	
Vågsfjord	27/3 »	»	170			2	154	13		0,013	11,8	
Røsthola	22/3 »	Fishtrawl	154	16	6	27	105			0,258		
S. W. Røst	31/3 »	»	94	16	4	20	51	3		0,392		
Tor Iversen bank	27/4 »	»	218	9	25	66	116	2		0,570		
Nordkappbank	2/5 »	»	136	21	6	1	108			0,009		
Sølebanken	1/5 »	»	142	73	21	3	43	2		0,070		
„G. O. S." st. 32	21/4 —51	Prawntrawl	81				1	1	79			0,013
Morsdalsfjord	28/10—50	»	295				182	9	41		20,2	0,220
Andfjord	27/10—49	»	124				122	2				
Ulsfjord	22/9 —50	»	356				82	7	267		11,7	0,026
Kvænangen	25/9 —50	»	144				144		3			

Although there are minor differences, the main features in the growth history of the young haddock seem to be the same in the whole area. Of considerable interest is the homogenity of the mean lengths of the samples of 0-group in the autumn 1948, only a month or two after the fry has taken to the bottom. This suggests a very uniform growth history in the pelagic stage.

Eggs and larvae.

In addition to these systematic investigations of young haddock some more casual observations of the distribution of eggs and larvae have been made.

Damas (1909) says that very few haddock larvae were captured farther north than the Romsdal Bank, and he infers that the mature fish of the Barents Sea must undertake great and rapid spawning migrations.

V. R. Aleev (1944) reports that considerable numbers of haddock eggs and larvae were found in May in the years 1934 and 1935 along the coastal banks from Vesterålen at 69° N northwards.

Norwegian plankton investigations which have been going on in this same area each year since 1948, show however (Wiborg 1950 and 1952) that only in the year 1948 some haddock eggs and larvae were captured here.

In the beginning of May 1951, a brief search for haddock eggs and larvae was undertaken covering the inner parts of the Helgeland banks south of Lofoten, from 67° N to 63° N with the research vessel "G. O. Sars" on her return trip from the Barents Sea. Only a few haddock eggs were found near the edge at the Træna bank 67° N. On a week's cruise with the "G. O. Sars" in search of fish eggs and larvae in the beginning of April 1952 covering the coastal banks from 70° N to 65° N, haddock eggs were found at one station only, over the edge at 65° N.

The spawning grounds of the northern Norwegian -and Barents Sea haddock must be of considerable dimensions, and it is unlikely that it has been overlooked in the plankton investigations mentioned above. These investigations indicate that the main spawning of the Barents Sea haddock in most years takes place south of the Lofoten area, and probably south of 65° N. This is confirmed by the regular yearly catches of big mature haddock in stages IV to V (Maier) taken in March—April by the trawlers on the coastal banks from Malangsgrunnen at 70° N to Røstbanken at 68° N.

Table 5. *Ranges and means of the brood-strength-quotients.*

	Brandsfjord	N.-Norway, Barents Sea
1947/1948 ..	0,03 – 0,20 } 0,09	0,01 – 0,57 } 0,15
	N = 11	N = 13
1948/1949 ..	2,5 – 18,8 } 10,78	11,7 – 26,5 } 17,70
	N = 8	N = 5
1949/1950 ..	0,03 – 0,17 } 0,12	0,01 – 0,22 } 0,09
	N = 7	N = 3

Table 6. *Mean lengths of samples of the 1948- and 1950 yeargroups from northern Norway and the Barents Sea, and from Brandsfjord. P.t.: prawntrawl. F.t. fishtrawl.*

Northern Norway, Barents Sea					Brandsfjord			
	1948-yeargroup:		N	$\bar{l}$	1948-yeargroup:		N	$\bar{l}$
Morsdalsfjord	25/9 —48	P.T.	162	12,78	2/9 —48	P.T.	28	14,39
Leirfjord	29/9 »	»	240	13,26		»		
Ulsfjord	16/10 »	»	167	14,63	9/10 »	»	173	15 29
Kvænangen I	19/10 »	»	163	14,08				
Kvænang. II	19/10 »	»	142	14,73				
Porsangerfj. .	23/10 »	»	142	14,25				
Andfjord	3/11 »	»	171	14,13	6/11 »	»	210	15,54
Ofotfjord ...	10/11 »	»	175	14,10				
Ofotfjord ...	10/8 —49	»	137	17,43	26/7 —49	»	139	17,42
Eidsfjord ...	28/9 »	»	189	19,92				
Kvænang. II	13/10 »	»	119	20,18	12/9 »	»	133	18,24
Ulsfjord	10/10 »	»	130	18,60				
Porsangerfj. .	18/10 »	»	70	20,83				
Andfjord	27/10 »	»	122	19,96	24/10 »	»	306	18,46
Vågsfjord....	27/3 —50	»	154	22,99	20/3 —50	»	86	20,68
Porsangerfj. .	3/5 »	»	159	24,20	30/5 »	»	75	22,34
Rosthola	22/3 —50	F.T.	105	22,50				
S.W. Røst ..	31/3 »	»	51	21,63				
Tor Iversenb.	27/4 »	»	116	25,37				
Sølebanken ..	1/5 »	»	43	23,77				
Nordkappbk.	2/5 »	»	108	22,31				
Ulsfjord	22/9 —50	P.T.	82	23,89				
Kvænang. II	25/9 »	»	141	26,22	27/9 —50	P.T.	26	25,87
Porsangerfj. .	29/9 »	»	110	28,05				
	1950-yeargroup				1950-yeargroup			
»G.O.S.« st. 32	21/4 —51	P.T.	79	16,98	28/3 —51	P.T.	149	17,02

Conclusion.

The uniformity in vertebrae number, brood strength and growth which has been shown to exist in young haddock from northern Norway and the Barents Sea implies that these areas are inhabited by one main population.

The main spawning ground of this population is probably located south of Lofoten.

It is to be hoped that future investigations (including tagging experiments) which are being planned, will soon give us further information of the life history of the haddock in this area.

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